Collection Efficiency of Particle Residues by Contact Swiping

The search for trace evidence often involves the contact swiping of surfaces with a cloth or similar material to collect any residues left behind. This type of sampling is used widely in the screening of luggage and other carry-on items at airports to collect particles of explosives that might indicate terrorist activity. Sampling pads designed to be placed directly in the front end of an ion mobility spectrometry (IMS) instrument are swiped over the surface of interest, and detection is directly related to collection efficiency. The development of sampling pads by the manufacturers of IMS instruments is generally proprietary, with competing requirements for low detector background and low cost in addition to high collection efficiency. A generalized procedure for determining collection efficiency could help in the continued development of better materials. We have developed a suite of microscopy tools that allow for large scale, automated mapping and counting of microparticles on a variety of surfaces for measurements of collection efficiency. We also have tools that allow for reproducible contact swiping and measurements of the forces with respect to particle location.

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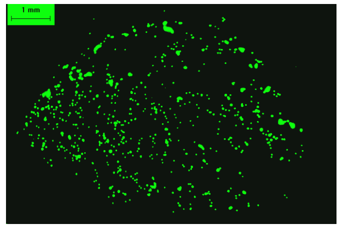
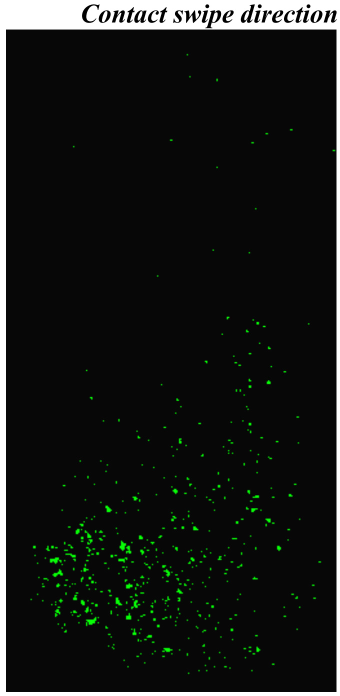
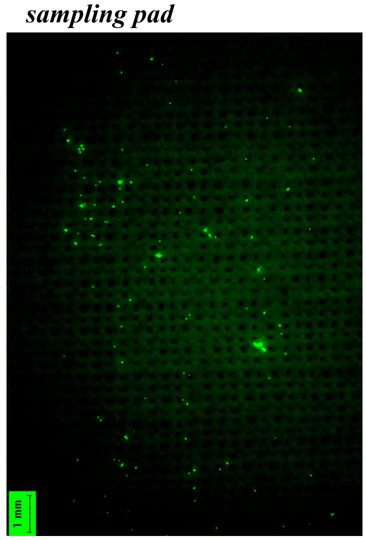
***1. Start:* 10 µm spheres on surface**



Contact swipe direction



***2. After*: spheres remaining on surface**
***3. After:* spheres collected on sampling pad**



The work described here contributes to a large, ongoing effort within NIST to study the particulate nature of explosives residues, and the efficient removal, collection, and detection of the particles by a variety of technologies. The efficiency of particle collection for ion mobility spectrometers (IMS) depends on a number of factors, including the adhesion of the particles to the surface; the contact geometry among surface, particles, and collection pad; the force of swiping; and the adhesion of the particles to the collection pad. The adhesion and removal of small particles has received considerable study, owing to the requirements in the semiconductor industry for clean wafer surfaces, and much is understood about the factors governing these processes. However, very little study has been applied to the subsequent collection of removed particles on a second surface, and no studies have been reported on particle removal and collection from surfaces of importance in airport screening environments using the types of sampling pads currently deployed.

Hi-tilt measurements from SEM and light microscopy provide measures of the particle adhesion on the surfaces studied.

This study was initiated under an agreement with the Transportation Security Laboratory (TSL), and the NIST results are expected to provide immediate feedback to improve the sampling protocols used in airports throughout the country.

The images demonstrate a procedure for measurement of collection efficiency. Particles are placed on the surface and counted by image analysis, and the particle counts after swiping and on the collection medium are used to determine collection efficiency. Composite images are collected by combining a large number of images to obtain the requisite resolution over large areas. Contact swiping experiments were conducted on four surfaces with 45 µm and 10 µm fluorescently-tagged polystyrene latex (PSL) spheres using two different sampling pads. The particles were placed on the surfaces using either a dry deposition technique, or by embedding the particles in an artificial sebum (skin oil) expected to be more representative of explosives particles in residues.

Primary conclusions include:

a) major differences in collection efficiency exist for the two different sampling pads,
b) large particles are collected more efficiently than small particles, and
c) the particles embedded in sebum are more efficiently collected off some of the surfaces than the dry-deposited particles.

The surface selected to be representative of canvas bags has very low collection efficiency under all conditions, indicating that an alternative method of sampling, such as vacuum collection, may be necessary.

Impact: Through the TSL, these results will impact sampling protocols at airports, and will stimulate development of better sampling pads by IMS manufacturers, further improving explosives detection at airports and other points of entry.

Future Plans: This activity will continue in order to study the removal of actual explosives residues, and to incorporate other questions posed by the TSL, such as changes in collection efficiency by multiple use of sampling pads.